

# AGITATION TYPE POWDER DISSOLVING APPARATUS FOR REPROCESSING SPENT NUCLEAR FUEL

## BACKGROUND OF THE INVENTION

The present invention relates to a dissolving apparatus for reprocessing spent nuclear fuel such as mixed oxide (MOX) fuel in a nuclear fuel cycle.

An example of slurry (powder) agitation apparatus is disclosed in Japanese Patent Laid-Open No.07-060093/1995. As shown in Fig.6, this agitation apparatus is designed to agitate powder 51 and liquid by agitating means 52 (an agitating blade) in an agitating tank 50.

When carrying out dissolution processing of spent nuclear fuel in such an agitation apparatus as described above, non-dissolved particles of powder are raised due to agitation of the agitating blade in a solution to disadvantageously leak from a solution outlet disposed on the upper part of the agitating tank.

## SUMMARY OF THE INVENTION

The present invention has been accomplished in view of the above-mentioned technical background, and it is an object of the present invention to provide an improvement that can prevent leakage of non-dissolved particles.

According to the present invention, there is provided an agitation type powder dissolving apparatus for reprocessing spent nuclear fuel, the apparatus comprising: a dissolving tank to which powder of spent nuclear fuel

is supplied; an agitating member rotatably disposed in the dissolving tank; and rise inhibiting means, disposed in the dissolving tank above the agitating member, for inhibiting the powder from swirling and rising due to the rotation of the agitating member.

In one embodiment of the present invention, the rise inhibiting means is composed of a plurality of fixed blades for causing the powder which would otherwise swirl and rise due to the rotation of the agitating member to move downward. Preferably, the fixed blade has a descending slope with respect to a swirling direction in swirling and rising. A top board having a number of distribution apertures is preferably disposed above the fixed blades.

In another embodiment of the present invention, the rise inhibiting means comprises a plurality of half-round shaped swirl and rise inhibiting plates which are arranged hierarchically, each of the inhibiting plates having a dimension such that the inhibiting plates overlap one another in the respective centers of frames thereof, and the inhibiting plate has a slope ascending outward.

In still another embodiment of the present invention, the rise inhibiting means comprises a reversed-conical shaped swirl and rise inhibiting member with a distribution hole formed in the center thereof.

In another aspect of the present invention, there is provided an agitation type powder dissolving apparatus for reprocessing spent nuclear fuel, the apparatus comprising: a dissolving tank to which powder of spent nuclear fuel is supplied; an agitating member rotatably disposed in the dissolving tank; rise inhibiting means, disposed in the dissolving tank above the agitating member, for inhibiting the powder from swirling and rising due to

the rotation of the agitating member; a powder supply system for supplying the powder of the spent nuclear fuel to a lower part of the dissolving tank; a nitric acid supply system for supplying nitric acid to the lower part of the dissolving tank; and a solution discharge system for discharging a solution including the powder dissolved in the nitric acid from an upper part of the dissolving tank.

### BRIEF DESCRIPTION OF THE DRAWINGS

Fig.1 is a longitudinal sectional view showing an example of an agitation type powder dissolving apparatus for reprocessing spent nuclear fuel according to a preferred embodiment of the present invention.

Fig.2A is a longitudinal sectional view showing an example of a dissolving tank according to the preferred embodiment of the present invention.

Fig.2B is a horizontal sectional view showing the dissolving tank of Fig.2A.

Fig.3A is a longitudinal sectional view showing another example of a dissolving tank according to the preferred embodiment of the present invention.

Fig.3B is a horizontal sectional view showing the dissolving tank of Fig.3A.

Fig.4A is a longitudinal sectional view showing still another example of a dissolving tank according to the preferred embodiment of the present invention.

Fig.4B is a horizontal sectional view showing the dissolving tank of

Fig.4A.

Fig.5 is a longitudinal sectional view showing a further example of a dissolving tank according to the preferred embodiment of the present invention.

Fig.6 shows an example of a prior art slurry agitation apparatus.

### PREFERRED EMBODIMENTS OF THE INVENTION

Some examples according to a preferred embodiment of the present invention will be described in detail hereinafter with reference to the accompanying drawings.

Now, an example as shown in Fig.1, Fig.2A and Fig.2B will be described below.

Fig.2A is a longitudinal sectional view of a dissolving tank, while Fig.2 B a horizontal sectional view thereof.

Although various kinds of spent nuclear fuel are to be reprocessed, MOX (Mixed Oxide) fuel will be explained as an example of the fuel.

A dissolving tank 1 is a longitudinal cylindrical vessel. In the dissolving tank 1, an agitating member (plate-like vertical agitation paddle) 3 is rotatably arranged. The dissolving tank 1 has its outer peripheral surface covered with a steam jacket 24, into which steam for heating is supplied.

Above the dissolving tank 1 is arranged a motor 8, which transmits its rotation to a shaft 2 supporting the agitating member 3 via a gear.

In the dissolving tank 1 above the agitating member 3, there are provided fixed blades 11 for serving as rise inhibiting means for inhibiting non-dissolved particles described later from swirling and rising in a solution.

Each of the fixed blades 11 is fan-shaped. A number of fixed blades are arranged around the shaft 2 side by side.

The fixed blade 11 is supported and fixed on the dissolving tank 1. The outer peripheral surface of the fixed blade 11 abuts against the inner surface of the dissolving tank 1, while the inner end of the blade is not in contact with the outer periphery of the shaft 2 to form a slight clearance therebetween. This clearance prevents the inner end of the fixed blade 11 from coming into contact with the outer periphery of the shaft 2 in rotation of the shaft 2.

The adjacent fixed blades 11 are arranged in such a manner that they overlap each other at the end portions thereof, and that each blade has a descending slope with respect to the direction of rotation of the agitating member 3.

A powder tank 7 for storage of MOX fuel and the like is connected to the lower part of the dissolving tank 1 via a powder supply pipe 5. A powder supply system which has the powder tank 7 and the powder supply pipe 5 further includes a valve provided midway along the supply pipe 5, thereby stopping the supply to the dissolving tank 1.

A nitric acid tank 6 for storage of nitric acid is connected to the lower part of the dissolving tank 1 via a nitric acid supply pipe 4. A nitric acid supply system which has the nitric acid tank 6 and the nitric acid supply pipe 4 further includes a valve provided midway along the supply pipe 4, thereby adjusting the supply amount of the nitric acid to the dissolving tank 1 and/or stopping the supply thereof.

A solution outlet is disposed on the upper part of the dissolving tank 1.

The vertical position of the solution outlet may be above the position of the fixed blades 11, and equal to or lower than the top position of the dissolving tank 1. This solution outlet is connected to a solution storage tank 17 via a solution discharge pipe 12. The solution storage tank 17 is further connected to a solution adjusting tank 18. A solution discharge system from the solution outlet to the solution adjusting tank 18 further includes a filter 14 and an electromagnetic valve 13 provided midway along the solution discharge pipe 12.

The steam jacket 24 has a steam inlet 9 on its lower part and a steam outlet 10 on its upper part. Steam having a temperature of about 60 °C to 80 °C is supplied to the steam jacket 24 to warm the dissolving tank 1 from its outer periphery. The above-described solution outlet is arranged at the slightly lower position than that of the steam outlet 10, so that the fluid level of a solution 20 is flush with the solution outlet.

On the upper part of the dissolving tank 1 (which is located upper than the solution outlet) is provided an off gas outlet for discharging therefrom an off gas ( $\text{NO}_x$ ) produced by a reaction between the MOX fuel and the nitric acid. The off gas outlet is connected to an off gas processing system 19 via an off gas discharge pipe 23. The off gas processing system 19 is further connected to the solution storage tank 17.

The dissolution reaction of powder of the MOX fuel is an exothermic reaction, thus leading to the possibility that bumping may occur. In order to recapture a solution included in the off gas ( $\text{NO}_x$ ) due to the bumping, the off gas processing system 19 is connected to the solution storage tank 17.

A steam jet pump 16 is disposed for discharging liquid with its suction

side connected to the bottom of the dissolving tank 1. The steam jet pump 16 for discharging liquid can discharge non-dissolved residue and the like accumulating in the bottom of the dissolving tank 1.

Three nitric acid concentration analyzers 15 are provided for measuring the concentration of nitric acid in the dissolving tank 1. In detail, the first concentration analyzer is arranged to measure the concentration of the nitric acid located in the bottom of the dissolving tank 1, the second analyzer to measure the concentration in the middle (between the agitating member 3 and the fixed blades 11) thereof, and the third analyzer to measure the concentration in the top (above the fixed blades 11) thereof. Thus, the nitric acid concentrations in the bottom, the middle, and the top of the dissolving tank 1 are measured by the nitric acid concentration analyzers 15. The valves in the powder supply system and the nitric acid supply system are used to adjust the supply amount of the powder and nitric acid solution, thereby keeping the state of dissolution good.

The MOX fuel and the nitric acid solution are supplied to the dissolving tank 1 from the powder tank 7 and the nitric acid tank 6, respectively, stirred and rotated with the agitating member 3, so that the dissolution of the MOX fuel proceeds. The dissolved solution overflows from the solution outlet disposed on the upper part of the dissolving tank 1 to flow to the solution storage tank 17 and/or the solution adjusting tank 18 via the solution discharge system.

In such dissolution processing, the rotation of the agitating member 3 causes swirling and rising flow above the agitating member 3. This flow has its outer periphery rising outward and swirling, with its center descending.

The non-dissolved fine particles (fine powder having a diameter of about 100  $\mu\text{m}$ ), which are being dissolved into a solution, ride on the swirling and rising flow to rise or ascend. Although the relatively large particles would sink because of its weight, the fine particles are so light that they can ride on the swirling and rising flow.

The non-dissolved fine particles which rise riding on the swirling and rising flow come into collision with the sloped fixed blades 11 disposed above the agitating member 3 to change its flow direction downward, resulting in little possibility that the non-dissolved particles rises across the fixed blades 11. This allows a highly concentrated solution to flow from the solution outlet, thereby preventing the non-dissolved particles from overflowing through the solution outlet.

The fixed blade 11 has a descending slope with respect to the direction of rotation of the agitating member 3 (namely, the swirling direction of the swirling and rising flow). In addition, the fixed blades 11 are arranged in such a manner that they overlap one another at the end portions thereof. This eliminates a clearance or gap between the fixed blades 11, preventing the non-dissolved particles riding on the swirling upflow from escaping from the clearance between the fixed blades 11 upward, thereby lessening the overflow of the non-dissolved particles.

Accordingly, this provides improvement in the speed of spent nuclear fuel reprocessing and in the ability to carry out the nuclear fuel cycle process.

Now, another example will be described with reference to Figs.3A and 3B.

Fig.3A shows a longitudinal sectional view of a dissolving tank, while

Fig.3B a horizontal sectional view thereof.

The following explanation about this example will show the different points from Fig.2. Elements in these figures that are in common to Fig.2 are given the same reference designators, and the description thereof will be omitted.

A plurality of swirl and rise inhibiting plates 11' serving as rise inhibiting means, each of which is half-round shaped, are arranged hierarchically such that they overlap one another in the respective centers of frames thereof. The swirl and rise inhibiting plate 11' is fixed with its outer peripheral surface abutting against the inner surface of the dissolving tank 1. In the center of its frame, the swirl and rise inhibiting plate 11' has a hole into which the shaft 2 is inserted. There is provided a clearance between the hole and the shaft 2 so that the shaft 2 is not brought into contact with the inner surface of the hole.

The swirl and rise inhibiting plate 11' has a slope ascending outward. The swirl and rise inhibiting means may be reversed-conical shaped.

The swirling and rising flow produced by the rotation of the agitating member 3 comes into collision with the swirl and rise inhibiting plate 11' to change its flow direction downward. Thus, there is little possibility that the non-dissolved particles flow from the solution outlet.

Now, still another example will be described with reference to Figs.4 A and 4B.

Fig.4A shows a longitudinal sectional view of a dissolving tank, while Fig.4B a horizontal sectional view thereof.

The following explanation about this example will show the different

points from Fig.2. Elements in these figures that are in common to Fig.2 are given the same reference designators, and the description thereof will be omitted.

A swirl and rise inhibiting vane 11" constituting the rise inhibiting means is reversed-conical shaped and formed of a board. This swirl and rise inhibiting vane 11" has a distribution hole formed in the center thereof, into which the shaft 2 is inserted.

The swirling and rising flow produced by the rotation of the agitating member 3 comes into collision with the swirl and rise inhibiting vane 11" to change its flow direction downward. There is little possibility that the non-dissolved particles flow from the solution outlet. Then the highly concentrated solution rises across the distribution hole to flow from the solution outlet.

Finally, a further example will be described below with reference to Fig.5 showing a longitudinal sectional view of a dissolving tank.

The following explanation about this example will show the different points from Fig.2. Elements in these figures that are in common to Fig.2 are given the same reference designators, and the description thereof will be omitted.

A top board 21 having a number of distribution apertures is disposed above the fixed blades 11, in which the example of Fig.5 differs from that of Fig.2.

The top board 21 disposed above the fixed blades 11 more effectively prevents the non-dissolved particles from rising in the solution. Thus, there is less possibility of the non-dissolved particles flowing out of the solution

outlet.

The appropriate selection of positions of the distribution apertures in the top board 21 with respect to the positions of the fixed blades 11 can lessen the overflow of the non-dissolved particles.

As can be seen from the foregoing, the present invention effectively prevents the non-dissolved particles from overflowing, thereby providing improvement in the speed with which spent nuclear fuel is reprocessed and in the ability to carry out the nuclear fuel cycle process.